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The FAA Technical Center Human Factors Laboratory Information Guide

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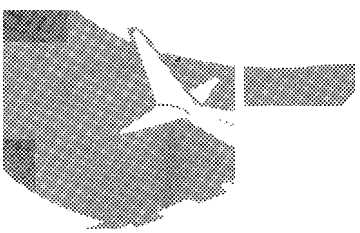

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16. Abstract

This information guide provides an overview of the capabilities of the FAA Technical Center's Human Factors Laboratory (HFL) and how those capabilities are being used to support research critical to the development and implementation of the National Airspace System (NAS).

The HFL was officially opened and dedicated on November 2, 1992. This unique state-of-the-art facility is the only one of its kind in the FAA. It is important that the information about this facility is made available not only to FAA organizations, but academic and private sector organizations as well.

This information guide specifically provides the reader with background on why the facility was developed, an in-depth overview of it's unique design capabilities, a description of the type of work the HFL will be engaged in, and a representative sampling of the directions and goals of the HFL.

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EXECUTIVE SUMMARY

An increasing awareness of the importance of human factors engineering in the development of aviation systems has prompted the development of a dedicated Human Factors Laboratory (HFL) to help ensure that systems being developed today for the 21st century are human-centered in their orientation.

In simple terms, human factors are characteristics of people. Characteristics such as size, weight, strength, gender, ability to see, ability to hear, temperament, intelligence, and memory must be taken into account so that people and systems made for their use work well together.

The HFL is used as part of the Federal Aviation Administration's (FAA) effort to ensure that aviation systems are designed to be usable and maintainable in a safe, efficient, and reliable manner. The HFL is housed in a 16,000 square foot facility in which approximately 9,000 square feet is a laboratory environment designed to support a variety of research projects as outlined in the FAA's "National Plan for Aviation Human Factors." Examples of such projects involve the evaluation of the effects of increased automation, proposed changes to air traffic control (ATC) operations and maintenance procedures, and resolution of human performance - related safety issues.

Highly trained research psychologists, engineers, programmers, and technicians work in a state-of-the-art, reconfigurable, and strictly controlled human performance measuring environment. They use sophisticated rapid-prototyping, modeling, simulation, and data collection equipment and techniques to perform their research. Multi-media performance measurement and analysis tools allow researchers to measure visual, auditory, psychomotor, and cognitive performance of pilots, air traffic controllers, and airways facilities technicians.

This facility was formally dedicated and opened on November 2, 1992.

With an increased focus on studying aviation human factors issues, the FAA can decrease the time and expense of design and development efforts, improve the usability and acceptability of new systems, and achieve vast improvements in safety, efficiency, and reliability.

Introduction

Welcome to the FAA Technical Center's Human Factors Laboratory (HFL). This Information Guide has been composed to provide you with a more detailed understanding of this facility.

The 1980s saw growing concern among aviation experts and legislators that along with the ever-increasing complexity of the National Airspace System there would be a greater opportunity for aviation-related accidents to occur that were, to some extent, associated with human performance. Out of this growing concern, the United States Congress passed a bill that instructed the Federal Aviation Administration (FAA) to initiate a program of long-term research to consider the role of the human operator in the development of next century's aviation systems.

The FAA responded to the Congressional direction by formulating the National Plan for Aviation Human Factors in 1990. This plan was designed to guide and coordinate aviation-related human factors research efforts being conducted by the FAA, other government organizations, academia, and private industry in the following areas: air traffic control (ATC), flight-deck automation, air-to-ground communications, aircraft maintenance, and airway facilities maintenance.

While many organizations have research facilities that can address individual elements of the Plan, no single facility has existed that has had the versatility to engage in the research, development, and evaluation of aviation *systems* from a human factors perspective. To ensure that the systems being developed for the 21st century are human-centered in their orientation, the FAA launched a new HFL at its Technical Center located at the Atlantic City International Airport in New Jersey.

The FAA Technical Center Human Factors Laboratory mission is to ensure that future aviation systems will be designed to be operable and maintainable and will ensure the uninterrupted flow of aviation safety, efficiency, and reliability.

The HFL has been designed to accommodate both applied and basic human factors research through a variety of rapid prototyping, simulation, data collection, and data reduction and analysis techniques. The capability to respond quickly to user needs and objectives was a key factor in the design of the HFL. The HFL meets this goal by providing a multipurpose and rapidly reconfigurable environment. Physical structures, voice and electronic communications, computers, and system peripherals have been designed to be easily modifiable and rapidly reconfigurable, and expandable to the fullest extent possible. Each of these rooms is interconnected by sophisticated communication networks. Additionally, the HFL is linked to other research facilities at the FAA Technical Center and throughout the country.

Facility Overview

The Laboratory is a multi-purpose facility that provides the flexibility needed to accommodate almost any human factors research or development effort. As such, all facets of the experimental environment -- walls, communications mediums, computers, and system peripherals -- are reconfigurable.

The HFL is housed in a 16,000 square foot, single story, raised floor facility on FAA Technical Center grounds. Approximately 9,000 square feet of this

space is dedicated laboratory space. The remainder of the space is an open environment office area accommodating the HFL's staff of 30 people. At the core of the HFL's laboratory facilities are four Experiment Rooms (ERs). Each ER is equipped with an adjacent Experiment Operator Station (EOS). Other support facilities include a:

Rapid Prototyping and Data Reduction Room

Blackroom with Audiometric Booth

Human Factors Library

Briefing Room

Reconfigurable Cockpit Simulator (RCS) Room

Multipurpose Room

Shared Equipment Room (SER)

General Purpose Laboratory (GPL)

Each of these rooms will be described, in turn, in greater detail later in this Information Guide. You may refer to figure 1 for the relative locations of these facilities within the HFL.

HFL CORE FACILITES: A CLOSER LOOK....

Experiment Rooms (ER) and Experiment Operator Stations (EOS)

The HFL is equipped with four Experiment Rooms (ERs). Each ER measures 15 feet by 20 feet (300 square feet of space). Two adjacent ERs can be combined to form a room 30 feet by 20 feet (600 square feet of space), if experiment requirements demand it.

Each ER consists of an area for subject-matter expert participation in an experiment and an adjacent Experiment Operator Station (EOS). Each EOS is an 8 foot by 10 foot room. The EOS serves as the central control location from which a researcher may monitor an experiment unobtrusively through an observation window. The ERs and EOSs incorporate sophisticated data, video, and audio communications capabilities.

To maintain control over the lighting environment, ERs incorporate both incandescent and florescent light sources. These light sources may be adjusted in a graduated manner and are computer controlled. Additionally, computer-controlled photometers are available to measure light levels and to enable the researcher to maintain constant light levels across experimental trials (should this be so desired). To maintain control over the sound-level while experiments are in progress, all ERs incorporate sound-attenuating material.

Each ER is outfitted with an array of multimedia recording equipment (i.e., video, audio, computer, etc.) that can be programmed and controlled from the EOS. This multimedia approach toward data collection enables the experimenter to record virtually all activities going on within the ER. To support this data collection capability, all audio, video, and computer data are time-stamped as they are collected using a time code generator (TCG) in the EOS. Each EOS TCG is linked to a master TCG located in the SER and can be linked to the master time or run in stand-alone mode. Along with containing a desktop computer for data collection and equipment configuration and control, each EOS contains pan and tilt controls for two ER

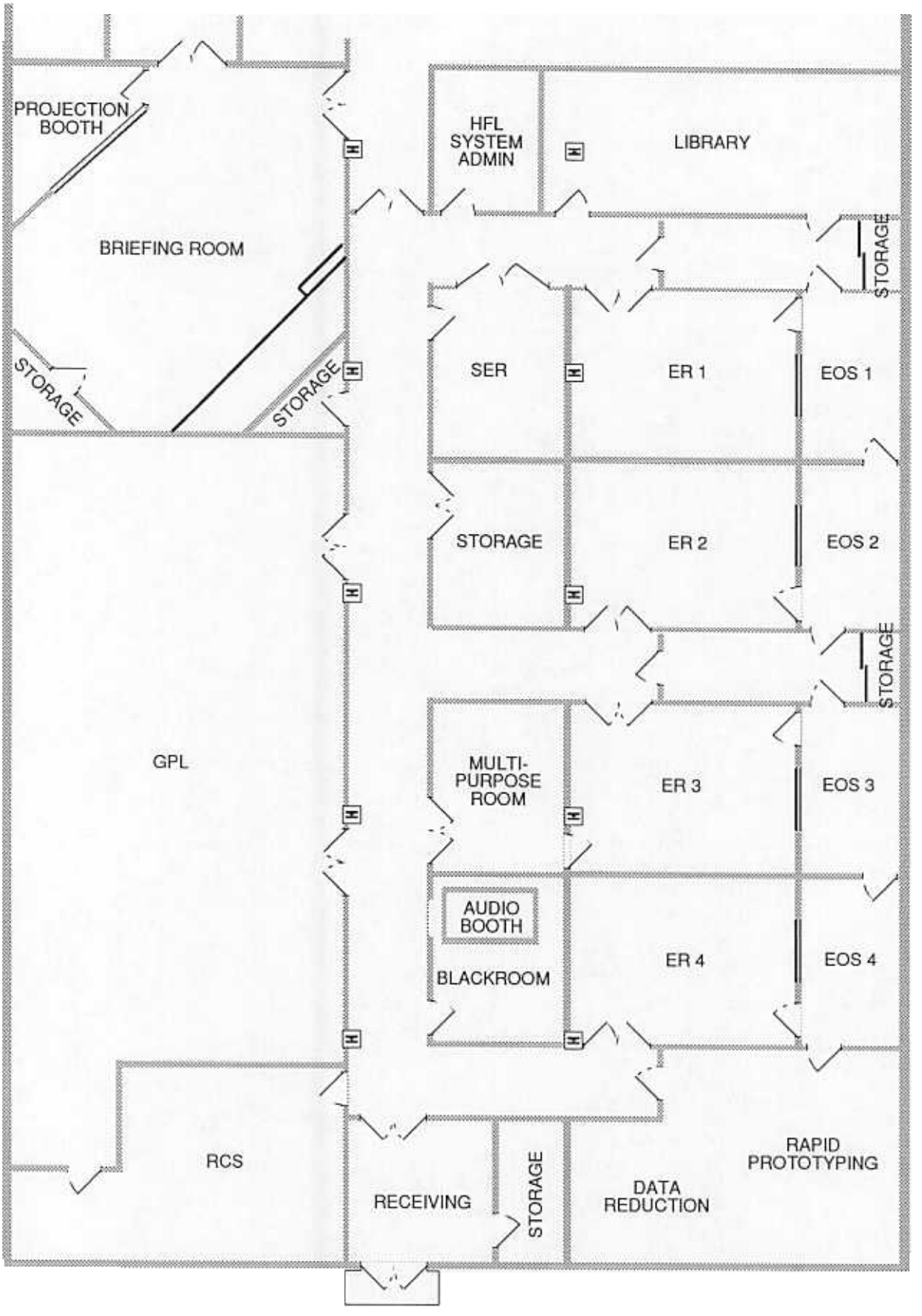

FIGURE 1. HFL FLOOR PLAN

video cameras, video tape recorders, video and audio routing equipment, multi-track audio recording equipment, voice communication equipment, a time code generator, lighting control equipment, video monitors, and speakers for monitoring activity in each ER. An on-line verbal annotation capability, which allows experimenters to attach notes to video recordings while an experiment is in progress, is also available to aid researchers in conducting data analysis activities post hoc.

Rapid Prototyping Area

The HFL provides rapid prototyping tools to study display and control design, anthropometric design, and job design. This affords the aviation human factors researcher the ability to quickly determine the format and functionality of hardware and software user-interfaces. This capability is further enhanced by the Laboratory's ability to then integrate these prototypes into real-time simulated operational scenarios.

The Rapid Prototyping Area provides a variety of hardware and software to develop, test, evaluate, and modify human-computer-interface (HCI) and workstation design concepts. The Rapid Prototyping Area contains the Macintosh II-FX, DOS-based, and Sun workstation platforms. The Area is equipped with a variety of commercial software tools such as MacroMind Director (Macintosh), Claris Hypercard (Macintosh), Asymetrix Toolbook (DOS), Protoview (DOS), and the Virtual Applications Prototyping System (VAPS) (SUN). All of these tools support the design, testing and verification and validation of user-interfaces. As previously noted, products in the form of developed prototypes can be quickly and easily integrated into real-time simulated operational scenarios for further development, test, and evaluation.

Data Reduction/Analysis Area

Since all computer-based equipment is automated to collect information regarding usage, researchers in the Laboratory are able to collect behavioral data such as operator response time, number of actions initiated, operator action sequences, etc. This method of data collection provides researchers with the required accuracy that could not otherwise be achieved through other methods of data collection.

To analyze data collected in the ER, data can be taken directly to the Data Reduction and Analysis Station situated within the Data Reduction and Analysis Area of the HFL. This multi-media data analysis Station permits the simultaneous review of video, audio, the user-interface activity, and human performance measures to uncover important relationships between variables as measured through the variety of media formats. This Station consists of a desktop computer, two visual displays (both have quad screen capability), a 16-track reel-to-reel recorder, audio and video editing capability, the capability to jog forward and backward one frame at a time, and the capability to review computer data such as the number and type of keystrokes that were input during the experiment. This type of analysis, for example, enables researchers to obtain insights into complex communications and decision-making activities such as is commonly of interest in controller team performance, pilot-controller communication, and critical incident analysis.

To further facilitate data reduction and analysis, an annotation capability permits researchers to append notes to video recordings while an experiment is in progress. This capability aids researchers in their post hoc data analysis activities.

The HFL provides capabilities for further analyzing and formatting the reduced data collected in the ERs. The Data Reduction and Analysis Area is equipped with the Statistical Analysis System (SAS), running on a Sun workstation. SAS-Graph provides for the creation of sophisticated and precise illustrations of statistical results. Other packages to support data analysis include Microsoft Excel,+ and Statistica, (available for both the DOS and Microsoft Windows environments).

Blackroom with Audiometric Booth

Research requiring more rigorous control of the lighting environment than is possible in the ERs is conducted in the Laboratory's Blackroom. This is a room that is furnished with minimally reflective black walls, ceiling, and floor. The Blackroom provides a completely "light tight" environment and is, for example, capable of supporting the research, development, and evaluation of advanced visual display technologies. The Blackroom measures approximately 15 feet by 12 feet for a total of 180 square feet.

Research requiring more rigorous control of sound-levels than is possible in the ERs is conducted in the Laboratory's semi-anechoic Audiometric Booth. This facility is, for example, capable of supporting the research, development and evaluation of advanced auditory display technologies, supporting subject-matter expert hearing tests, and supporting the simulation of operational environments where auditory criteria are critical.

Reconfigurable Cockpit Simulator (RCS) Room

There has been an ever-accelerating trend away from mechanical flight instrumentation and towards electronic flight instrumentation, or more commonly referred to as "glass cockpit technology". This technology has the potential to present the flight crew with critical information in a much more efficient manner than mechanical flight instrumentation was capable of. Much human factors research is needed to enhance the reliability and information transfer efficiency of the glass cockpit environment to the flight crew. The HFL provides the environment in which to conduct this much needed work.

Situated within the HFL is the Datalink Program's RCS. This RCS is a system capable of simulating the instrument panels of many different aircraft. Using a suite of Silicon Graphics computers, high-resolution graphic monitors, and sophisticated software, the system is capable of simulating a Captain's instrument panel, a center instrument panel, a First Officer's instrument panel, an instrument panel of a center console, and an out-of-the-window visual world. High resolution graphics monitors are used for the instrument panels and out-of-the-window visual scenery. The RCS is equipped with functional flight controls. The RCS is also equipped with actual flight controls such as control columns, throttle quadrant, rudder pedals and landing gear controls that perform in a realistic fashion for added realism. It is also equipped with hardware to emulate the Flight Management System (FMS), Control and Display Units (CDU), the Auto Pilot

Mode Control Panel, the Radio Control Panel, the Electronic Flight Instrumentation System (EFIS) Control Panel, and the Engine Indication and Crew Alerting System (EICAS) Control Panel. With quick and simple software modifications, virtually every instrument can be rapidly modified in its functionality and location, as well as its physical features.

The RCS can communicate with the HFL's Initial Sector Suite System (ISSS) Common Console Simulators located in ER#3 to form a test bed with which to study air-to-ground communication issues and has been the primary tool used to support airborne data link research. The ISSS Common Console Simulators are discussed further under Air Traffic Simulation on page 10. The system can also communicate with the FAA Technical Center's Target Generation Facility (TGF) which enables it to participate in ATC simulations along with other cockpit simulators that are also linked to the TGF.

Multipurpose Room

The Multipurpose Room is quite unique in this facility. It has the distinction of being the only room for which a multitude of activities may occur. Since the room is equipped with a battery of Sun Sparcstations, it would not be unusual to find computer programmers writing software code that would support future experiments. Alternatively, it would also not be unusual to find researchers and subject matter experts working together to rapidly prototype a new interface concept. Other functions planned for this room are limited only by the imagination, but might include the room serving as a pre-brief area for subject matter experts that will participate in experiments, or as a room in which to study the social psychological dynamics of team decision-making. In essence, the Multipurpose room is just that -- multipurpose in nature; a room that can be used for preparing for experiments as well as conducting them.

General Purpose Laboratory (GPL)

The GPL supports both the HFL and the National Simulation Capability (NSC) by providing the engineering resources necessary to conduct diverse experiments. Staffed by a team of engineers and scientists, the GPL's purpose is to develop or customize hardware and software under evaluation in the HFL.

The GPL is equipped with a variety of computer systems that may be rapidly customized to support a given experiment. Test equipment facilitates the interfacing and integration of HFL/NSC experiments with other research organizations, such as universities, private industry and other government laboratories. Within the GPL, one finds the unglamorous elements necessary to produce the dynamic simulations conducted in the ERs (i.e., raw integrated circuits, wire, prototyping boards and hundreds of reference manuals, etc.). Most importantly, the GPL is staffed by a team that understands the details that make up the various components of the National Airspace System (NAS) function.

The GPL allows for rapidly-prototyped interfaces to be converted to functional prototypes that may be deployed for actual field evaluation. Also, the GPL supports the PHASE III enhancements of the General NAS Sector (GNAS) Maintenance Control Center (MCC) -- the primary human-interface for performing 21st century airway facilities maintenance automation. The real-time weather information displays

developed for this effort have been ported to the FAA Technical Center's Administrative Local Area Network (LAN) and are maintained through the GPL.

HFL SUPPORT FACILITIES: A CLOSER LOOK...

Human Factors Library

The Laboratory houses a dedicated Human Factors Library that serves as a resource to researchers in the aviation human factors community that are working within the Laboratory. The Library holds an extensive collection of books, journals, technical reports, military standards, and government documents relevant to human factors and related disciplines. The Library also uses CD-ROM technology and on-line data-base technology to facilitate the rapid collection of specific information. This Library will, very shortly, become one of the primary resources for human factors literature throughout the world.

Briefing Room With Projection Booth

In the Briefing Room, visitors to the HFL can view experiments in progress in an attractive and comfortable auditorium environment. This briefing room provides the capability for observers to simul-aneously monitor the activities of separate experiments on three separately controlled large-screen projection systems. Visitors can monitor the audio, video, and computer screens (in real-time) for a given ER. The Laboratory's briefing room contains three audio and video systems, each displaying one of three views of the activities being conducted in a given ER. Each visitor can select and switch among the three views available on each audio and video system. The Briefing Room is also equipped to serve as an environment in which to offer professional presentations using a variety of media.

Next to the Briefing Room is a Projection Booth that controls the visual and auditory information being presented. This room contains equipment to control slide and view graph presentations, audio tapes, multiple screen video presentations, and the display of RGB video from computer displays. The Projection Booth also provides connectivity to and presentation of all information available on the Technical Center's closed-circuit television system.

Shared Equipment Room (SER) And Communications Systems

The SER is the nerve center for the HFL. All HFL communications networks culminate in the SER to allow the sharing of HFL equipment, resources, and information. The SER also contains all the equipment necessary to link the HFL with other facilities both within and external to the FAA Technical Center.

The HFL's communications networks provide for the interconnection of a variety of HFL elements to share audio, video, and computer information. A 10 Base 2 Ethernet system connects the various SUN workstations, X Terminals, and DOS-based platforms. A broadband system distributes the audio and video signals throughout the building. A separate Fiber Optic Cable Plant provides Fiber Optic Inter-Repeater Link (FOIRL) ports throughout the HFL. The FOIRL is used primarily to support the HFL's Administrative LAN An Interbuilding Link (IBL) provides connectivity from the HFL to the Technical Center's Technical Building.

The IBL consists of three pairs of multi-mode fibers and one coaxial Broadband link. Two pairs of fiber are used for the Fiber Distributed Data Interface (FDDI) backbone, and one pair is used to connect the Channel Bank Equipment. The FDDI backbone provides high speed connectivity between various LANs in the Technical Building and the LAN's in the HFL. The HFL's Ethernet and Administrative LAN are both bridged onto the FDDI backbone. The Channel Bank provides connectivity for additional data traffic that is not networked, as well as voice communications that are used during ATC simulations. The Channel Bank multiplexes the voice and data and transmits the signal to the Technical Building by way of a T1 fiber modem. (The FDDI and the Channel Bank have a complementary unit in the Telephone Room of the Technical Building.)

The Broadband System is, in essence, a cable TV system that facilitates audio and video communications throughout the HFL, and provides a link to the TV studio in the Technical Building. Experiments can be monitored from any office or cubicle in the HFL and can be transmitted to the Technical Building for monitoring there. Alternatively, each ER or the entire HFL can be isolated by way of a key switch in the SER.

The SER contains all primary networking equipment for the HFL. One bridged hub provides connectivity to the FOIRL ports throughout the HFL. The other bridged hub provides connectivity to the Ethernet that specifically serves the laboratory. Each ER/EOS combination has been partitioned into Ethernet sub-networks that are connected by way of bridges. This, for example, isolates ER3/EOS3 communications traffic to its own network. The bridges permit the passing of information across networks only when desired and does not slow down the entire network when a communication-intensive experiment is taking place. Similarly, the RCS Room, the Data Reduction and Analysis Area, Rapid Prototyping Area, Multipurpose Room, and GPL are also configured in this manner for superior network throughput.

The master router is a compound matrix switch that controls audio, video, and RGB signals. The router is remotely controlled from the Projection Booth, and provides primary control of the Briefing Room audio and visual systems. It also allows audio and video signals to be routed to and from the four EOSs and the RCS. The RGB portion of the router allows people in the Briefing Room to monitor experiments in progress on the high-resolution projection system. RGB inputs are provided from the RCS and Common Consoles in ER3, but are reconfigurable depending upon experiment requirements.

The Voice Communication System (VCS) rack is also located in the SER. This system has access ports throughout the HFL that are used to simulate ATC voice communications systems, and air-to-ground voice communications for the RCS. VCS positions are also located in the EOSs so that the experimenter can monitor the experiment, record the activity on a 16-track tape recorder, and even communicate with the subjects. The VCS has been designed so that the VCS positions, or key panels, can simulate the push-button point-to-point communications used in ATC systems, or can simulate a cockpit radio by dialing in a simulated frequency. The VCS is a stand alone system, but can be linked to the Technical Building by way of the Channel

Bank and linked to other voice systems to serve larger simulations.

Computing Resources

In order to support research and development, the HFL contains a computer network which presently consists of a suite of Sun workstations, (three Sun 4m/670s, one Sparcstation 10, 5 Sparcstation 1+, and one Sun 3/280) running UNIX supporting X11 and Openwindows environments, 4 high performance X terminals, various personal computers, two Macintosh IIfx workstations, and a Silicon Graphics Workstation Network to support the RCS. Additional X terminal support is being added to high end performance PCs through the addition of TCP/IP and X terminal software. The additional X terminal capability will permit all users to access all UNIX-based hosts from both remote locations and their daily workstation areas. All computer equipment is networked. These networks permit the HFL's computer systems to communicate with the Novell based Administrative LAN and the TCP/IP based LANs in the Technical Building. Direct connection is possible to the Technical Building's TGF, Data Link, TATCA and NASPAC Laboratories. As other facilities come on-line they will be immediately accessible. All computing and networking capabilities will be periodically upgraded in order to keep current with technological advancements. The HFL computer systems also have access to Internet allowing high speed data transfers between government, industrial and educational institutions throughout the United States and the world. Dial-up access is being integrated into the HFL. 2400 baud access is available at present with 9600 baud access anticipated in the future. At present, the HFL can support the development of X11, Openwindows, C and FORTRAN-based applications.

Human Performance Measurement Equipment

Along with audio, video, and computer apparatus, a number of other dedicated research capabilities exist. An ASL series 4000 oculometer is available for use. An Autogenics BioLab 14000 system is available for eletromyographic measurements, electroencephalograms (EEG), heart rate variability, eloctromyocardiograms (EMG), galvanic skin response (GSR), and blood pressure. Audiometric research is supported with the provision of a semi-anechoic chamber, an audiometer, and a frequency analyzer. A number of small-scale DOS-based human factors packages and paper-and-pencil assessment tools are available as well.

FOCUS OF HFL RESEARCH AND DEVELOPMENT

The areas of focus described below are but a small subset of the work ongoing in the HFL. They will, however, provide you with a representative sampling of the directions, goals, and emphases of the HFL.

Human Performance Measurement Development

Many new systems and products in industry are released to the public each year and many are promoted as having been designed according to ergonomic guidelines. Many promotions are specific in their human performance benefits such as reducing workload, increasing situation awareness, reducing visual fatigue, reducing

cumulative muscle trauma, etc. Yet, many of these claims are without foundation since, in many instances, the techniques to assess those specific human performance constructs do not yet exist in valid and reliable forms.

One of the principle ongoing goals of the HFL researchers is to develop and refine the methods used to assess the measurement of human performance. This work, of course, is not being performed in isolation, however. It is realized that there are human factors researchers throughout the world that are working toward the same goals. It is therefore, the intention of HFL researchers to coordinate, when appropriate, with researchers elsewhere in the human factors community to develop and refine human performance measurement tools that are valid and reliable across operational domains.

Human Performance Measurement Assessment and Prediction

There are many NAS systems that will be developed in the very near future. In fact, many are currently in the process of being developed. One of the goals of the HFL research team is to aid in the development of these systems according to the human-centered design philosophy. This philosophy posits that one must begin with considering the consequences of the demands that will be placed on the end-user when the system is finally constructed. That is, one must first consider the human limitations and capabilities of the NAS operator before one builds the system otherwise, as has happened many times before throughout history, one will end up with a system that is very difficult (and potentially dangerous) to use.

The HFL research team is actively engaged in the design of NAS systems. The team not only provides assessments of the measurement of human performance using prototypes but also provides human performance predictions as to the likelihood of levels of workload, stress, boredom, errors, fatigue, etc., that is likely to be experienced by NAS operators under contingent design configurations. The ability to assess and predict the impact of a system's design on human performance is critical to designing systems correctly and cost-efficiently from the initial stages.

Air Traffic Simulation

Researchers in the HFL are able to conduct human factors studies of the interface and the allocation of functions of the new Advanced Automation System's (AAS) ISSS Common Consoles using real-time simulations. Researchers also have available to them a small-scale ATC simulator to investigate more generic issues of ATC radar operation. The Laboratory anticipates eventually housing a small-scale ATC tower simulator in which researchers can work to enhance the information needs of this highly specialized job.

Four ISSS Common Console Simulators (CCS) reside in ER3. The simulators use the same high-resolution 20 inch main displays and 19 inch auxiliary displays as the actual Common Consoles. The simulators are driven by Sun Sparcstation 670 computers. Besides looking like the actual Common Consoles, the CCS meet the same anthropometric criteria as the actual consoles. Trackballs and keyboards are provided which look and perform as the actual Common Console equipment. Four display consoles, which can be configured as either EnRoute PVDs

or ARTS IIIA displays, exist for simulations involving the existing Terminal and EnRoute environment. ATC simulation software presently consists of standard and modified versions of the Center/TRACON Automation System (CTAS). CTAS can receive simulated aircraft from the TGF to support real-time simulations. The AT Coach ATC Training system is presently being acquired to provide additional Terminal and EnRoute real-time simulation capability.

Advanced Display and Control Concepts

New technologies are proliferating in this age of the computer. In just the past few years, the working world has witnessed the introduction of the touch screen display, surround-sound technology, virtual reality, and heads-up-displays, to name but a few.

With this proliferation of technology comes the danger of its misuse. For example, while touch screen displays are certainly effective for some environments, they are not appropriate in all environments. The human factors researchers are obligated to assess the potential usefulness of new technologies for the NAS and to identify when and where these new technologies might be useful in making the NAS operator's job easier.

User-interface Design

One of the consequences of the ever-increasing complexity of the NAS is that new, potentially useful pieces of information are made available to the NAS operator in areas where it may not have existed before. That is, the new NAS systems can provide the human user with more information than he/she would ever hope to have. All of this newly provided information is useless, however, if they are not provided in an efficient and timely manner.

The researchers in the HFL are tasked with ensuring that new NAS components adhere to general cognitive engineering guidelines. This approach will ensure that users will not become overloaded, confused, or delayed because of a poorly designed information display. In essence, the HFL researchers are working to reduce the potential for system-induced human error.

Expert Training Systems and Job Aid System Development

As we move further into the era of the intelligent computer, there is a great potential for these systems to be quite helpful to the NAS operator when he/she is training or when in the field. The HFL research team is actively engaged in an ongoing effort to develop expert system tools for both the airway facilities technician and the air traffic controller that will serve as aids to enhancing the quality of his/her training. The team is also engaged in developing portable job aids that can be carried to the field by the airway facilities technician and can be incorporated into ATC computer algorithms that will serve as aids to these NAS operators and will help them to continue to perform their job efficiently.

Communications Analysis

Voice communication is an essential component of the daily functionality in the NAS. Unfortunately, missed, misunderstood, or misinterpreted voice communications between the pilot and the controller account for a large proportion of air traffic incidents. As a result, there has arisen a need to

investigate voice communications to improve the reliability of these communications.

The Laboratory provides the capability to investigate the parameters of voice communications within the NAS and is able to support the research, development, and evaluation of advanced voice communications technologies. Such facilities and tools as the semi-anechoic Audiometric Booth, sound measurement devices, and a complex voice communications system enable researchers to explore ways in which to ensure that voice communications are both audible and intelligible.

In some instances, it may be considered practical to use either synthesized speech output or speech recognition technology. In fact, the FAA's new technologies for the ATC tower will incorporate speech recognition technology. As the need for these technologies grows, there will inevitably be new human factors challenges to overcome. The Laboratory is able to meet these challenges by providing the researcher with an array of sophisticated speech recognition and synthetic speech systems that may be used in the development of user interfaces.

Aviation Security

Unfortunately, we are living in a less than perfectly secure world. And one of the most obvious targets of terrorism in this century has been the commercial air carrier.

New systems are currently being designed that will help the aviation security screener to better perform the job of identifying potential threats to air safety from terrorist activities. It is recognized, though, that even the most advanced system will still require the human operator to make the valued judgments and assessments that current computer technology does not enable detection systems to perform. The HFL research team is actively engaged in an ongoing research effort to support the Aviation Security Human Factors Research and Development Program in conducting human factors research, development, test and evaluation. Human factors efforts focus on improving training methods for aviation security screeners, conducting human performance assessments using newly developed detection technologies, and developing and evaluating user-interface components associated with these detection technologies.

Workstation Design

NAS systems are generally composed of two major components: the computer monitor and the workstation console. Just as it is necessary to attend to the design of the user-interface, it is also necessary to attend to the ergonomic aspects of the workstation console design. The goals of ergonomic consideration of the workstation design is not only a matter of comfort, it is also a matter of considering the potential impact of the workstation on human performance and health. Poorly designed workstations, for example, can cause premature fatigue, muscle ache, eyestrain, cumulative muscle traumas such as the now infamous 'cumulative hand trauma' being experienced by many operators who use computers intensively in their daily jobs. The HFL research team is actively engaged in ensuring that the design of NAS workstations adhere to ergonomic guidelines. This work includes the development of guidelines for specific workstation consoles as well as the

assessment of consoles well along the development phase.

Connectivity To Other Laboratory Facilities

The results of aviation human factors research collected at the Laboratory (and other institutions conducting aviation human factors research) will not be useful unless it can be easily shared in a timely fashion. To facilitate the exchange of information, the Laboratory possesses extensive networking capabilities.

Multiple fibers and coax cables have been run between the HFL and the main Technical Building to provide connectivity to the NAS Simulation Support Facility (NSSF) which includes the TGF and external cockpit simulators, the EnRoute simulation laboratory, the Terminal simulation laboratories, the Oceanic Development Facility, the Administrative LAN, the Television Facility, and other facilities. This connectivity provides the capability for the HFL to serve as a node on the network of facilities that make up the NSC. The Laboratory can transmit text communications and data to other facilities at the Technical Center as well to other government laboratories, academia, and private industry, through Internet.

Summary

The Laboratory is designed to serve as a resource to the entire aviation human factors community and, as the 21st century NAS evolves, so too will the Laboratory. The Laboratory was officially dedicated on November 2, 1992. Tours of the Laboratory are provided upon request. For further information, please contact the Federal Aviation Administration Technical Center, ACD-350, Atlantic City International Airport, New Jersey 08405; Telephone: (609) 485-4751.

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